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FEASIBILITY TESTS OF SELECTED STIMULI AND DEVICES TO DRIVE LIVESTOCK

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SUMMARY

Experiments were conducted to determine the response of livestock to lights, sounds, air blasts, electricity, and mechanical sweeps for the purpose of developing design criteria for automatic driving and penning devices for livestock markets. The experiments were made with cattle, hogs, and sheep. The test stimuli and devices were hung on trolleys that were moved on tracks above the alleys.

In the tests, the livestock were moved best by a mechanical sweep (a wooden gate of alley width and height). Electric shocks, air blasts, and the amplified human voice were the next most effective.

The animals gave little or no response to incandescent, infrared, mercury vapor, or xenon lights.

A mechanical sweep with electrically charged bars is recommended as the most feasible device for driving livestock. The sweep should be the full width of the alley and slightly higher than it. To minimize high voltage dangers to operating personnel, the sweep should be remotely controlled.

A mechanical sweep with compressed air jets is the second recommendation for a driving device, and a sweep accompanied by the amplified human voice is the third.

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FEASIBILITY TESTS OF SELECTED STIMULI AND DEVICES TO DRIVE LIVESTOCK

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BACKGROUND OF THE STUDY

In 1964 there were about 1,800 livestock auction markets and 58 terminal stockyards operating in the United States. Both types of livestock market use the same methods of driving and penning animals that were in use when livestock markets were first established in the United States over a century ago: Yard workers on foot or on horseback drive the animals to a pen, open the gate, drive the animals into the pen, and close the gate. Excessive labor costs are common. A few auction markets have installed hydraulic systems that mechanically open and close gates near the auction ring, to control the flow of livestock. These gates are costly and, in most cases, have failed to reduce the markets' labor requirements. Furthermore, the cost and complexity of such gates preclude their use to open and close the large number of pen gates in the yards proper.

This study was made to determine the response of livestock to certain stimuli and devices for the purpose of developing design criteria for automatic driving and penning devices for use in livestock markets.

Cattle, hogs, and sheep were tested singly and in groups ranging up to 10 animals under environmental conditions that exist in stockyards and auction markets.

The stimuli and devices used were as follows:

1. Light rays of different candlepower, intensity, and bands of the spectrum.

2. Sounds of different pitch and intensity.

3. Air blasts.

4. Electricity applied at different voltages and by various means.

5. A mechanical sweep or driver (a wooden gate of alley width and height).

1/ The research on which this report is based was done by the American Research and Manufacturing Corporation under contract with the U.S. Department of Agriculture.

MATERIALS AND PROCEDURES

A test facility was constructed at the Baltimore Union Stockyard, Baltimore, Md. (fig. 1). The test area consisted of a covered alley and an open alley forming a corner; two hog and sheep pens; and two cattle pens. This facility covered 4,128 square feet. Existing facilities--pens, alleys, electrical service, and so forth--were not adequate for the tests, so electrical capacity and services were added and fence supports were strengthened and alined. An observation platform was constructed over the open alley and an instrument room was built in the corner formed by the two alleys.

An overhead trolley running the width of the alley was installed in each alley (fig. 2). The test devices were hung from the front of each trolley and connected to the instrument room. Separate tracks and trolleys were used in the two alleys to facilitate continuous movement of livestock from one alley to the other, without the use of switches or curved rails.

The trolley tracks were constructed of commercially available slotted angle iron in 12-foot lengths. The trolleys were made of slotted angle iron of lighter gage than the tracks; they had rubber-tired wheels. An endless loop of 3/8-inch-diameter rope was tied to the trolley and looped around pulleys at each end of the alley. The trolleys were hand operated because it was felt that this was adequate for exploratory experimentation.

Each test device was hung on the trolleys by 0.375-inch eyebolts.

The device to hold the lights used in the tests was made of exterior grade plywood, reinforced with slotted steel angle iron at top and bottom (fig. 3). Light sockets on the device were protected by a fabricated aluminum guard. The lights were powered from a 220-volt, alternating current, three-wire grounded neutral line. Heavy-duty, rubber-covered cables provided a flexible connection from the instrument room to the trolley.

Sound was administered through a 60-watt loudspeaker and a 100-watt amplifier. A voltmeter was used to measure the power going into the speaker to maintain the power below 60 watts. Maintaining power at about 50 watts was sufficient to generate a 120-decibel intensity level 15 feet from the speaker.

The electrical shock probe assembly was constructed of slotted angle iron with 11 porcelain insulators bolted to the underside (fig. 4). From the tips of each insulator extended a steel rod, 15 inches long and 0.0625 inch in diameter, terminating in a brass ball 0.5 inch in diameter. The rods were connected with No. 18 gage high-voltage wire to a 5,000 volt direct current power supply. A motorized switch was used to pulse the high voltage.

The air blast device consisted of two extra-neavy pipe sections, 10 feet long, 0.5 inch in diameter, with 10 nozzles, 0.125 inch in diameter, projecting down 90 degrees from the center line of the pipes. The pipes

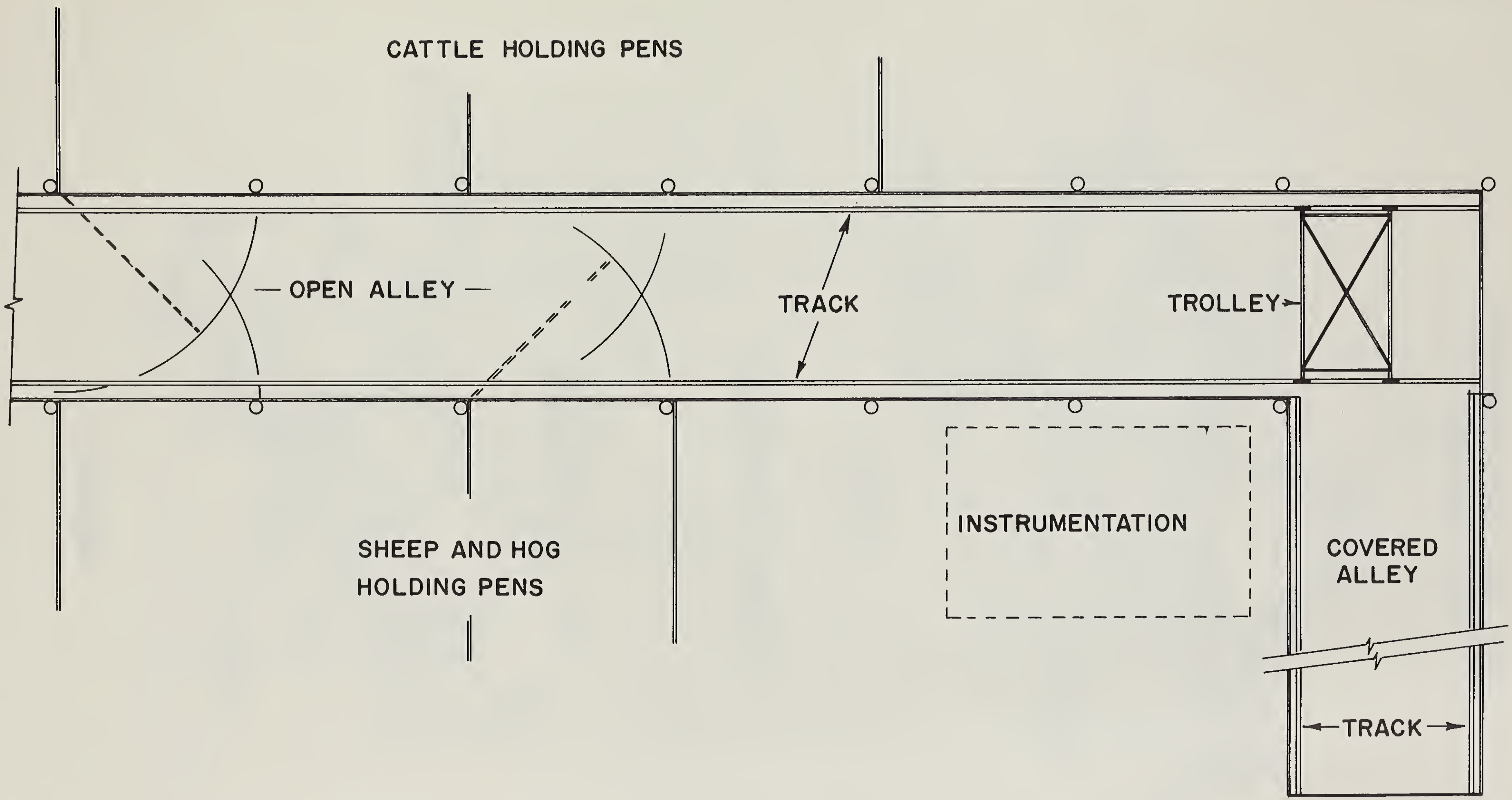

Figure 1.--Layout of the test facility at the livestock market.

TROLLEY FOR MOUNTING TEST DEVICES

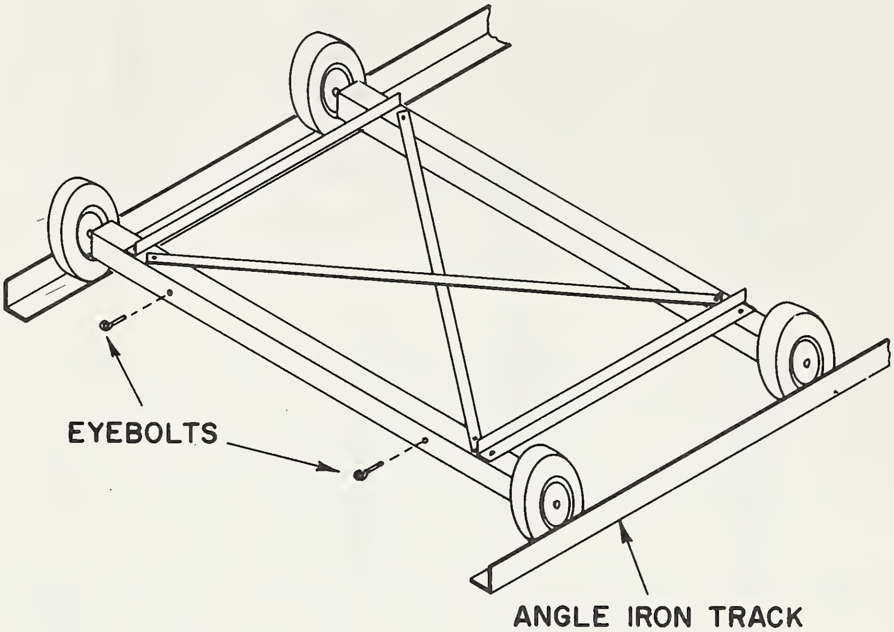

Figure 2

LIGHT MOUNTING

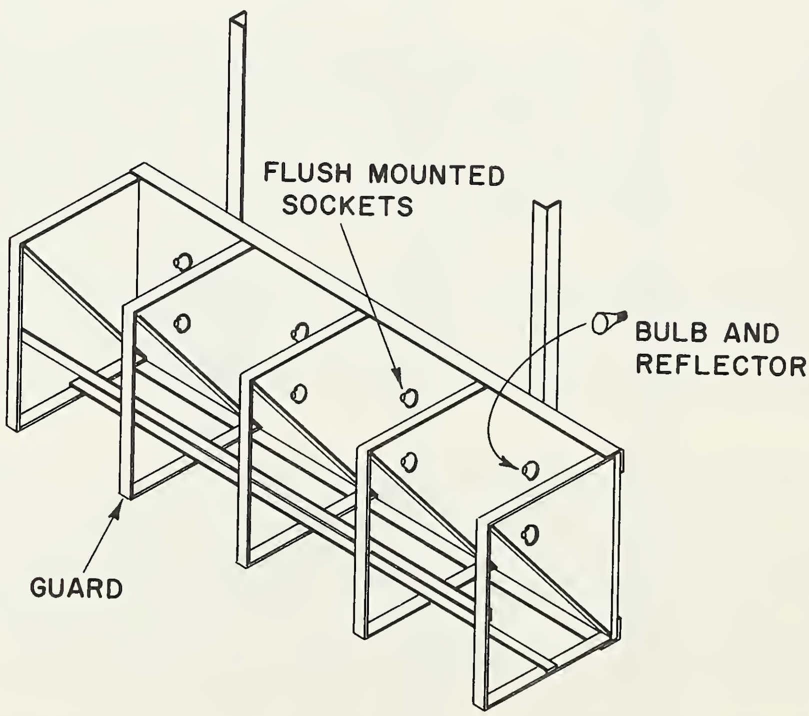

Figure 3

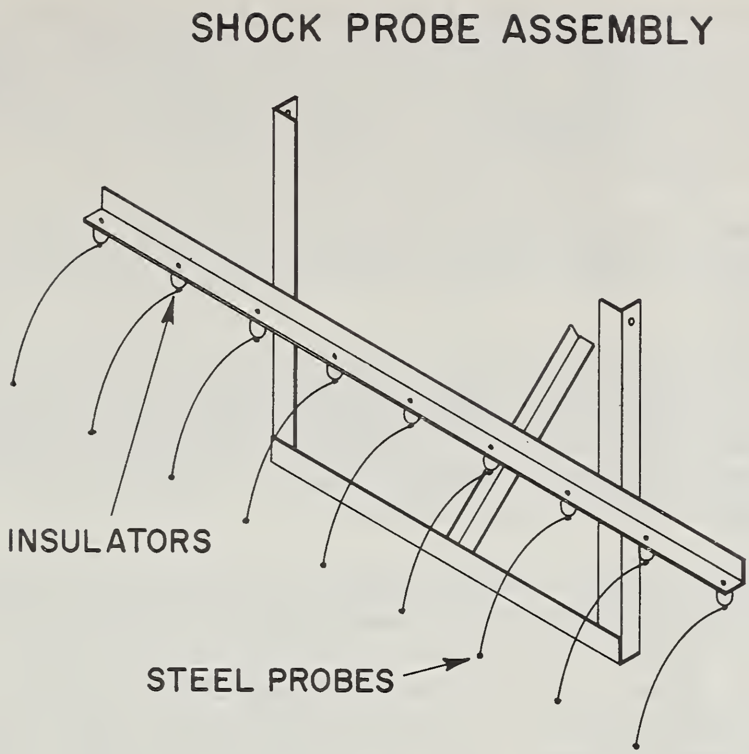

Figure 4

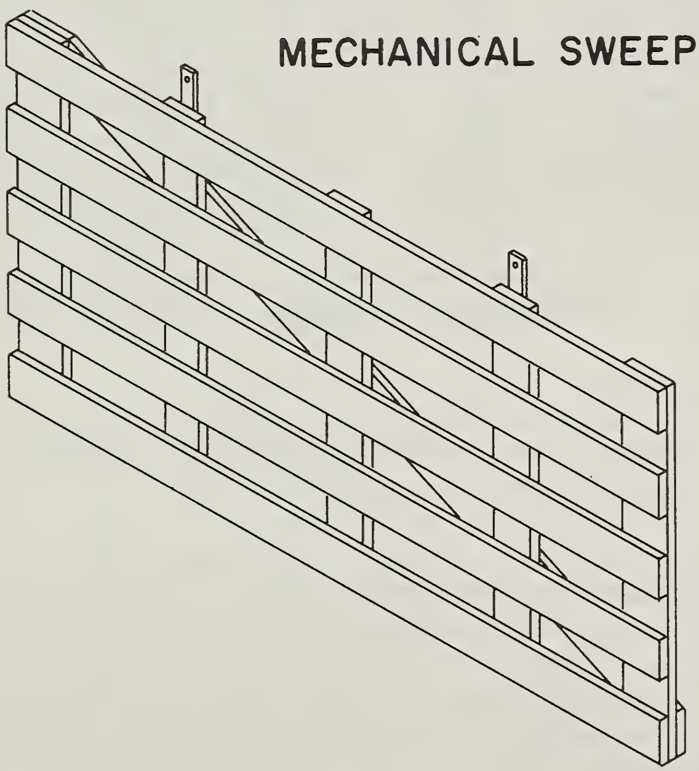

Figure 5

were 18 and 48 inches from the ground when hung horizontally on the trolley. The height was changed as needed in the tests, and nozzles of smaller diameter were used in some tests. The pipes were connected by electrically operated solenoid valves to a 200 p.s.i. (pounds per square inch) gasoline-driven compressor with self-storing high-pressure hose.

The mechanical sweep was of simple wood construction, consisting of 1- by 6-inch boards (fig. 5). The sweep formed a barrier across the full width of the alley.

The test devices were hung from the front of each trolley and connected to the instrument room. Electrical power supplies and the electronic equipment were housed in the instrument console. Leading from the instrument room was a 30-foot length of cable, terminating in a hand-held pushbutton, to provide for remote control of the test devices.

Tests were run 5 days a week during January and February 1964. The animals were driven into the alley at one end, and the testing device was positioned at the opposite end. The testing device was then turned on. If the animals immediately moved in the opposite direction from the device, the device was moved toward the animals to determine to what extent the stimuli would cause continued movement away from the device. If there was no immediate response when the device was activated, the animals were driven toward the device to determine at what point, if any, animals reacted to a particular stimulus. In tests with lights, sounds, and air blasts, if the animals moved away when the stimulus was turned on, the device was moved after them to force their continued movement. In the tests with electric shocks and the mechanical sweep, the test device was moved so that direct contact was made with the animals. After the device touched the animals, no attempt was made to force continued contact. No attempt was made to use the stimuli to force animals against a barrier or into a specific pen.

The experiments were divided into two series. Series I was exploratory and determined thresholds of sensitivity and general reactions of animals to a wide variety of stimuli.

Series II consisted of additional tests of stimuli that were found to be effective in the first series, new tests derived from information from the first series, and various combinations of stimuli.

Various types and breeds of cattle, sheep, and hogs were used in the tests (table 1). A high turnover of livestock was necessary to overcome conditioning problems. After repeated testing, some groups of livestock became useless to the program because they were unwilling to return to the test area without use of abusive driving methods, which would have greatly affected the test results. In addition, livestock were exchanged to prevent their learning the routine of testing.

Table 1.--Data on livestock used in tests

Livestock in tests	Weight per animal 1/	Remarks
	Pounds	
Cattle:		
1 Ayrshire steer	1,050	Previously used for 18 months in medical experiments
1 Angus steer	830	Active animal
9 Hereford steers	867	Well finished
14 Hereford steers	1,200	Very tense; healthy
2 Holstein steers	1,000	Very docile; became nervous because of experiments
1 Holstein bull	1,060	Alert, healthy, and quick
9 Holstein cows and 1 Guernsey cow ..	1,155	Several were milking
Hogs:		
10 Hampshire--3 male, 7 female	203	Well finished
10 Yorkshire--8 male, 2 female	225	Well finished
1 Chester White boar	155	Slow moving and indifferent
10 Hampshire--6 male, 4 female	197	Very healthy and active
Lambs:		
8 Southdown--5 male, 3 female	97	1 crippled, not eating well; 2 limping; others in good condition
14 Hampshire--8 male, 6 female	90	Well finished
10 Shropshire--7 male, 3 female	93	Sizes varied; some had been sheared

1/ All weights for more than one animal are averages.

To avoid conditioning the livestock too rapidly, test alleys were alternated and the livestock were brought into the test area from different directions. When it became apparent that the livestock, through fear or conditioning, would not enter the test area, that particular test was discontinued for a short time, usually 30 minutes to 1 hour. During this time, the livestock were allowed to rest.

Although weather conditions affected the experiments, no significant difficulty was experienced. Moderate rain, snow, or wind was easily tolerated. Heavy snow had to be shoveled to clear the alleys and gates to allow movement of equipment and livestock.

RESULTS, SERIES I EXPERIMENTS

Thirty experiments were run during the first series. The following stimuli were used:

- Lights
  - 14 incandescent lamps, parabolic reflectors, 100 watts each; yellow, green, blue, red, and a mixture of the 4 colors.
  - 8 infrared reflector lamps, 250 watts.
  - 1 mercury vapor lamp, 400 watts.
  - 1 xenon-filled flash tube with reflector (rated at 300 watt-second).
- Sound, intensity levels of 90, 100, 110, and 120 decibels.
  - White noise[2/]--continuous, pulsed 2 to 4 times per second, and single pulses of 1 second duration.
  - Sinusoidal sound,[3/] in single tones, frequency range of about 50 to 44,000 cycles per second--continuous, pulsed 2 to 4 times per second, and single pulses of 1 second duration.
  - Human voices simulating a drover's cries, amplified to high-intensity level.
- Electric shock, ranging from 1,000 to 5,000 volts in steps of 1,000 volts, pulsed 30 times per second.
- Mechanical sweep--wooden gate the width of the alley.

Lights

Some of the livestock tested, particularly cattle, showed some curiosity toward the lights, favoring yellow slightly. As each experiment was repeated with a different color on a particular group of livestock, the curiosity and interest decreased until finally the lights were ignored completely. Hogs and sheep paid no attention whatsoever to the lights. The group of nine Hereford steers paid the greatest attention to the incandescent lights. As with other cattle tested, they favored yellow.

When infrared heat lamps were used, no particular reaction was noted. All of the livestock tested ignored the heat lamps completely. Many of the livestock did not hesitate to touch the aluminum guard on the test device.

2/ Random sound such as that produced by depressing all keys on a piano simultaneously.

3/ Steady pattern of high- and low-pitched sounds such as the wail of a siren.

The mercury vapor lamp was bright enough to have a blinding effect on humans looking directly at it. When the livestock were driven down the alley toward the lamp, they went directly past the lamp; some of them even looked directly into the lamp without any observable effect. A few of the livestock showed minor curiosity, but usually they ignored the lamp completely.

When the xenon flashing light was used, none of the groups tested paid any particular attention to it. Some of the cattle flinched slightly when the light flashed, but did not move. Only one flash a minute could be used since a comparatively long interval was required to recharge the storage capacitors between flashes. Each flash lasted only a few milliseconds.

Sound

During the sound experiments, the livestock were driven down the alley toward the loudspeaker and allowed to stand still 15 to 20 feet in front of the loudspeaker. The sound was then applied.

The hogs and sheep did not move as a result of the white noise. However, they did appear to be bothered emotionally by the noise as the intensity levels were increased.

Frequencies of sinusoidal sound up to 11,000 c.p.s. (cycles per second) were applied through the loudspeaker. Sounds above 11,000 c.p.s. were applied through a supertweeter, which has a response of 3,000 to 44,000 c.p.s. Cattle were most sensitive to sounds within a frequency range of 500 to 5,000 c.p.s.; they showed no response above 12,000 c.p.s.

During single-tone tests, the cattle were repelled when the sound was varied in pitch from 50 to 600 c.p.s. and 600 to 6,000 c.p.s. to give a sirenlike effect. The cattle also reacted more strongly to sounds that were pulsed at the rate of 2 to 4 times per second than they did to steady tones. The animals moved away from the source of some of the sinusoidal and white noise sounds. However, there usually were delays of 5 to 10 seconds before the livestock moved. Hogs seemed bothered by the sounds, but they did not move. The hogs merely stood still during the entire experiment. This was true of all the sounds in the full range of frequencies, making it impossible to determine the frequency sensitive range of the hogs.

The human voice was used through a microphone and the amplifier, to simulate a drover's cries. The response to the cries was very high, especially by cattle; one animal jumped with all four feet off the ground simultaneously and moved away from the sound almost instantly. The most positive response was obtained from a group of nine Hereford steers.

Electric Shock

All livestock tested reacted to electric shock, but the thresholds varied. At about 2,000 volts, the cattle reacted when the electric prods touched ears, nose, or legs. The tougher hide on the back and sides could be penetrated by 3,000 and 4,000 volts. The hogs reacted when the prods touched ears and nose

at 1,000 volts, but as much as 4,000 volts was necessary to penetrate the tough hide on the back of Hampshire hogs. Only 2,000 volts was required to penetrate the hide of Yorkshire hogs. After being shocked once or twice, a hog would no longer go near the prods and it squealed violently when driven toward them. The sheep were much less sensitive to voltages because it was impossible to penetrate the long wool fibers of the back and sides. They could only be shocked through the nose, ears, and base of the legs. They did not react violently to any of the voltages, and only mild responses were noted. The cattle tested could not be driven (even forcibly) toward the prods after one or two shocks.

In all the electrical shock tests, the moisture content of the ground was a factor. Ground impedance measured during the tests varied from about 1,000 to 50,000 ohms. Wet ground gave lower impedance readings than dry ground. Ground soaked with urine gave the lowest readings. The internal impedance of the power supply was about 1 megohm; therefore, the ground impedance was relatively unimportant. However, it was found that the covered alley, if perfectly dry, could not conduct at all, and therefore the stimulus was ineffective. All of the electrical shock tests were therefore run in the uncovered alley.

Mechanical Sweep

The mechanical sweep was used on lambs and cattle. This method proved very effective in moving the livestock. If the livestock stopped, the sweep was moved so that it touched them, and the livestock would move again. When one Ayrshire steer was driven back toward the mechanical sweep, he tried to squeeze between the sweep and the edge of the alley. He succeeded in knocking the overhead carriage off its track and damaging it slightly. As a result of this, the trolley was reinforced and equipped with devices to prevent derailing.

RESULTS, SERIES II EXPERIMENTS

Because lights were ineffective in the first series of tests, no further light experiments were conducted. Instead, more tests with various sounds were tried. It was believed that those sounds which were steady and monotone were less effective than those which varied either in intensity or in pitch. Sounds pulsed at an even rate were also less effective than those in which the pulse rate and duration were varied. The most effective sound of all was the human voice.

Thirty-seven experiments were run during the second series. The following stimuli were used:

- Sound, intensity levels between 90 and 120 decibels.
  - White noise--continuous, pulsed 2 to 4 times per second, and single pulses of 1 second duration.
  - Sinusoidal sound, in single tones ranging in frequency from about 50 to 12,000 c.p.s.--continuous, pulsed 2 to 4 times per second; pulses of 1 second duration, pulsed 10 times per second; varying pitch to give a sirenlike effect; and single continuous tones at varying intensity.

Human voices simulating a drover's cries, amplified to high intensity.

Recorded thunderstorm.

Rock-and-roll music with vocal.

Soft music.

Recorded auctioneer's voice.

- Electric shock, 1,000 to 5,000 volts, in steps of 1,000 volts--pulsed 30 times per second.

  A hand-held, battery-operated shocking device.

- Animated sweep--strips of cloth dangling from the overhead trolley; black, orange, and blue cloth separately and the three colors together.

- Animated sweep and white noise at 110 db intensity.

- Air blasts from 10 nozzles, spaced 10 inches apart, of 0.125-inch diameter, on a pipe 12, 18, 36, or 48 inches above the ground.

Sound

Hereford steers reacted fairly well to most sounds, particularly steady tones of about 600 c.p.s. and sirenlike sounds varying in pitch between 500 and 6,000 c.p.s. Of all the sound experiments, the best response of the Herefords was to the human voice at a sound intensity level of 110 to 120 decibels. The livestock instantly moved away from the source of the sound (fig. 6). This was verified when the herd was divided into smaller groups of five and when the cattle were run singly. The results from the human voice were considerably less at levels between 90 and 100 db, than between 110 and 120 db.

Sinusoidal sounds were not effective in moving Hampshire lambs, although there was evidence that they heard the sounds and paid some attention to them. When 500 c.p.s. was pulsed 10 times per second, the lambs moved slowly away from the source of sound. They also moved away from the sirenlike sound varying in frequency between 600 and 6,000 c.p.s.

Two Holstein steers were tested together. The first test was sinusoidal sound. The results were very disappointing at first, with no response to any of the sounds applied. This was true even with the sirenlike sounds which had been so effective with the Hereford steers. When the white noise tests were run later, the same steers were motivated very strongly. A mild reaction was obtained with the thunderstorm recording, and a very strong reaction was obtained with the rock-and-roll music. However, as tests progressed further and the auctioneer's voice was used, the steers became too highly excited to continue. After these tests, they could not be driven back into the test area.

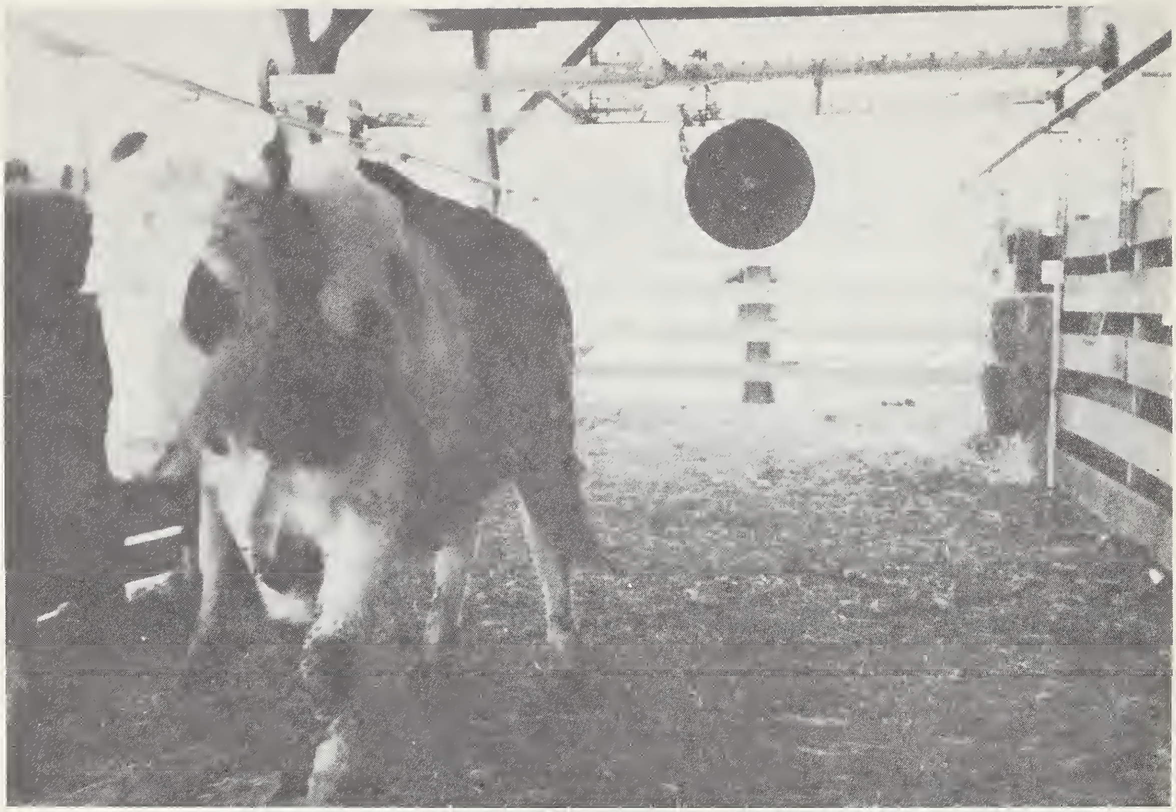

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Figure 6.--Cow moving away from sound device.

A Holstein bull gave a medium response to pulses of white noise and pulsated 1,000-c.p.s. sinusoidal sound. The bull did not respond to pure steady tones of sinusoidal sound. Very strong responses were obtained from human voices, including the drover's cries, the auctioneer's voice, and the singer of rock-and-roll music. Soft music had no effect whatsoever. During the 15-minute-long thunderstorm recording, the bull started to move up the alley and then stopped.

The first tests of a Chester White boar were with bursts of white noise. The boar moved quickly away from the source of sound. When sinusoidal sound was used, he did not respond except at 1,000 c.p.s. applied continuously. This caused a medium response; the boar slowly walked away from the source of sound. All other sounds produced absolutely no motion. During the thunderstorm recording, the boar merely crouched down, obviously bothered by the sound, but refused to move. The boar shivered with increasing intensity during the remainder of the noise tests, which lasted about half an hour.

Shropshire lambs gave no response whatsoever during the entire sequence of sound tests.

A group of dairy cows, 9 Holstein and 1 Guernsey, gave a very high response to single pulses of white noise. A high response was also obtained at 500 c.p.s. applied continuously. No response was obtained at 12,000 c.p.s.,

but high responses were obtained from sounds in the frequency range of 6,000 to 11,000 c.p.s. The sound tests later had to be discontinued because the cows refused to return to the test area without being driven by abusive methods. In fact, one of the cows damaged a fence while trying to get back into the cattle holding pen and away from the test area.

Electric Shock

The electrical shock experiments of Series II were run for the purpose of adding to the data already obtained during Series I.

Electrical shocks of 2,000 volts were found to be the minimum threshold of sensitivity of Hereford steers. With 3,500 volts the steers very quickly moved away. The test was then run with no voltage in the prods and the steers quickly moved away. After this, the steers refused to come near the prods and could not be driven into them.

The threshold of sensitivity of Hampshire lambs was found to be 4,000 volts; 5,000 volts were required to obtain a high response. At voltages between 2,000 and 4,000, they responded slightly but only when the prods touched their noses.

The threshold of sensitivity of two Holstein steers seemed to be about 1,000 volts; 3,000 volts were required for a high response.

The responses of a Holstein bull were very similar to those of the Holstein steers, except that slightly higher voltages were required. A medium response was obtained from 3,000 volts. Further electrical shock tests on the bull were not possible because he could not be returned to the test area without use of abusive driving methods.

The threshold of sensitivity of a Chester White boar appeared to be about 2,000 volts, and a high response was obtained at 4,000 volts. The sweep did not repel him, however, and he ran through the electrically charged sweep, squealing each time he touched the prods. When 5,000 volts were applied, results were the same.

One test was conducted on the Hereford steers using a hand-held, battery-operated shocking device. This method was very effective on the backs and thighs. The steers moved instantaneously with short running steps.

Animated Sweep

During the experiments, it was felt that a mechanical sweep might be more effective if parts of it were allowed to move violently and independently. Instead of the wooden gate used in the Series I experiments, the sweep used in Series II consisted of thin strips of cloth dangling from the overhead trolley. The strips of cloth were approximately 4 inches wide and long enough to reach almost to the ground, flimsy enough so that any of the livestock could easily walk through without feeling them, yet creating a strong visual effect. There was usually enough breeze to move the strips vigorously.

A group of 14 Hereford steers was divided into smaller groups of 3 or 4 each and driven into the alley. All of the steers stopped, refusing to go through the cloth. When the animated sweep was driven toward them, they turned quickly in the other direction. Black, orange, and blue strips were each tried separately and all the colors were used simultaneously. No noticeable difference in response was obtained. The cattle went through the strips of cloth if driven hard.

When the Holstein bull was tested, he noticed the strips of cloth but showed no fear or hesitation and went right through them.

The animated sweep was also tried on 14 Hampshire lambs. At first the method worked very well; the lambs ran ahead of the sweep as it followed them. After a few applications, however, they seemed to get used to the streamers and lost most of their fear, and the method was no longer effective.

The animated sweep did not work on the Chester White boar. The boar walked right through the streamers as if they were not there.

The animated sweep was tried in combination with white noise on cattle and lambs. As the livestock approached the streamers, a burst of white noise at a level of 110 db was applied. This was extremely effective, both in preventing the livestock from going through the streamers and in inducing them to turn around and move in the opposite direction.

Air Blasts

Two groups of five Hampshire hogs were used in the air blast tests. The discharge pipe for the air blasts was about 18 inches above the ground during the first experiment, and an air tank pressure of 200 p.s.i. was used. When the air was released, the temperature at the nozzles dropped at least 5 degrees below the ambient temperature. The actual temperature drop may have been much greater, however, as the thermal delay of the thermometer prevented accurate measurement. An audible sound at an intensity of about 92 db accompanied each burst.

The hogs were run down the alley toward the sweep. The air was discharged when the hogs were approximately 18 inches away from the jets. The results were excellent; the hogs immediately turned and ran in the opposite direction.

The jets were later mounted 3 feet from the ground at a 45-degree angle downward. The response was not quite as great as the first time, but still effective. During this test, the air compressor was running and was putting out about 90 db of sound. This may have had a tendency to drown out the noise coming directly from the discharge nozzles.

The test with the discharge pipe 18 inches from the ground was run on the Chester White boar. When the boar was driven toward the air nozzles, he stood still and refused to go past the nozzles. The test was repeated, moving the sweep with jets toward the hog. As the sweep moved toward him, he moved ahead of the sweep as long as the air jets were discharging.

The discharge pipe was raised to 3 feet from the ground for tests with the Holstein bull. The bull ran away from the air jets very quickly. For the second test, 10 minutes later, the bull was so frightened of the sweep that he could not be driven close enough to the air jets. For the third test, the bull was forced into the alley by hard driving methods. The sound of the air jets was enough to make him run in the opposite direction, although he had not been close enough to actually feel the air.

The discharge pipe was lowered to 1 foot from the ground for tests of Shropshire lambs. The 10 nozzles were changed so that they each had an 0.0625-inch-diameter orifice. The sound level measurement upon discharge was still 92 db. The tests with nozzles of this size were slightly less effective than those with the larger orifices, although a high response was obtained during most of the tests. Occasionally, one of the lambs decided to jump over the pipe and others would follow. Once some of the group had started over the pipe, further air blasts were ineffective in preventing the rest of the group from following. Later tests on the same lambs were found to be much less effective, and when a low pressure of 100 p.s.i. was used, the lambs ignored the blasts altogether.

The air blast experiments were run on 10 dairy cows (9 Holsteins and 1 Guernsey). The discharge pipe was 3 feet from the ground. Air pressure was 200 p.s.i. The air blasts were very effective in moving the cows, both singly and in small groups. The reactions of cows in groups of four each were much stronger than those of single cows; cows in the groups reached the panic stage. After one or two tests, it was almost impossible to drive the livestock back toward the air jets. No particular difference in response was noted between the Guernsey and the Holsteins.

CONCLUSIONS AND RECOMMENDATIONS

Some of the advantages and disadvantages of the stimuli and devices studied as possible devices for driving livestock are given in table 2.

The following devices, listed in the order of greatest effectiveness, are considered the most feasible for driving livestock.

Mechanical Sweep With Electrically Charged Bars

A powered mechanical sweep with electrically charged bars, operating on tracks, appears to offer the most promise. The sweep should be the width of the alley and should extend from the ground to a height above that of the fencing, to effectively sweep the livestock forward. It may be necessary in some installations to employ two sweeps, one in front and one behind each livestock group to prevent individual animals from straying. Each sweep could be controlled individually, or the two could be controlled simultaneously for precise placement of the livestock. An aluminum or corrosion-resistant steel sweep with rubber-tired wheels is to be preferred over a metal-wheel device, primarily to facilitate movement, provide silent travel, and for best corrosion resistance.

Table 2.--Evaluation of selected stimuli and devices for driving livestock

Stimulus or device	Advantages	Disadvantages	Feasibility of use for driving livestock
Mercury vapor lamps	None	No effect on livestock. Time required to reach full intensity is 15 minutes. Cannot be looked at directly by humans without discomfort.	None
Flashing xenon lamps	None	No effect on livestock.	None
Colored lights: red, blue, green, yellow	None	No effect on livestock. Bulb breakage possibility.	None
Infrared heat lamps	None	No effect on livestock. Bulb breakage possibility.	None
White noise sound	Pulsated white noise caused movement away from source. Equipment portable and inexpensive.	High sound level could affect other livestock in adjacent pens.	Good
Sinusoidal sound	Varying frequency caused immediate movement away from source. Equipment portable and inexpensive.	High sound level could affect other livestock; could be painful to humans.	Second best of sound stimuli.
Human voice (amplified)	Caused immediate movement away from source. Equipment portable and inexpensive.	High sound level could affect other livestock; could be annoying to humans.	Best of sound stimuli.
Air blast	Caused immediate movement away from source.	High initial investment for equipment and high upkeep.	Good to very good.
Electrical probe	Caused immediate movement away from source.	High voltage danger to personnel. Physical contact necessary to be effective.	Excellent. Best of all single media tested for initial movement.
Mechanical sweep	Caused immediate movement away from source.	High initial investment for track installation and equipment necessary to automate the yards.	Excellent. Very best for initial and sustained movement when combined with electrical probe.

The sweep would have two electrically charged bars (with ground return bars to localize effective shock area) running the full width of the alley. The bars would be attached at heights of 18 inches and 48 inches to effectively reach either small or large livestock.

A central console, located to give a full view of the alley in use, could be used to control the sweep and minimize high voltage dangers to operating personnel.

Mechanical Sweep With Compressed Air Jets

Attached to the front of a mechanical sweep, and extending the full alley width, would be two air pipes mounted at heights of 18 inches and 48 inches respectively. Each pipe would be equipped with approximately 10 nozzles, 0.125 inch in diameter. These air pipes would be connected by self-storing hoses to a central compressor supplying 150 to 200 p.s.i. of pressure. Capacity of the compressor would be determined by the number of air jets installed.

Mechanical Sweep With Amplified Sound

A suitable loudspeaker, amplifier, microphone, etc., would be mounted on the movable sweep in lieu of the high voltage bars. The most effective sounds were the human voice at sound intensity levels of about 90 db. This level can be obtained with an amplifier and loudspeaker with about 20-watt capacity. Although sinusoidal sounds, especially fluctuating frequencies such as a siren, were very effective on cattle, they are annoying to personnel and may be confused with distress signals such as civil defense, police, ambulance, and fire. Sinusoidal sounds are therefore not recommended.

The sound should be accompanied by a secondary stimulus; for example, a plain or animated mechanical sweep to maintain continuous movement. Amplified sounds of any kind, however, may also influence livestock in pens adjacent to the alley.

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